Influence of Fat Level on Physico-chemical, Textural and Sensory Attributes of Dry-cured Duck "Salchichón"

Fat Level on Dry-cured Duck "Salchichón"

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Abstract

The effect of fat content (0 and 10%) on physico-chemical, colour, textural and sensory attributes of dry-cured duck "salchichón" was studied. Insignificant differences (P>0.05) were observed in pH and moisture content between the two batches manufactured. However, fat level showed significant differences respect to fat content (10.2 vs. 22.4%; P<0.001), protein content (43.1 vs. 34.3%, P<0.001) and ash content (5.8 vs. 4.9%, P<0.001) for batches manufactured without and with fat, respectively. The highest fat level produced an increased in the lightness (29.24 vs. 36.10, P<0.001) and yellowness (10.40 vs. 7.25, P<0.01) and a decrease in redness (18.61 vs. 15.55, P<0.01) of sausages. An increase in shear force (7.74 vs. 5.32 kg/cm2) has been observed with the decrease in the level fat in dry-cured duck "salchichón". With regard to sensory properties, fat level, fat distribution, cohesiveness, hardness and juiciness were significantly different respect to fat content. The principal component analysis offered a good separation of the mean samples according to fat level.

Keywords

Duck Dry-fermented "Salchichón"; Fat Level ; Physico-chemical Properties; Sensory Attributes; CIE L a* b**

Introduction

Meat products such dry-cured sausages are associated with nutrients and nutritional profiles that are often considered negative, for instance saturated fatty acids, cholesterol, sodium or high caloric content (Whitney & Rolfes, 2002). There is growing evidence that fat in the dietary content plays a significant role in the incidence of chronic disorders, particularly in cardiovascular diseases (Hu et al., 2001). Reduction of fat in meats can be minimized by selection of lean meat cuts or removal of adipose fat. In addition, the reduction of fat in meat products offers processorsthe opportunity of improvement in the nutritional and health qualities of their products (Fernandez Ginés et al., 2005). In recent years, increasing concerns about the potential health risks associated with the consumption of high-fat foods has led to the development of new formulations in food industry or to modification of traditional food products containing less fat (Mendoza et al., 2001).

Other possibilities present in the market are the consumption of meat products of lean species. Modern consumers are willing to purchase new products, which is what meat products from alternative species can feature (Hoffman & Wiklund, 2006), for example duck meat and elaborated meat products from duck. In this sense, duck meat represents an available alternative for use as a raw material (breast cut) in preparation of cured sausages due to its low fat content (Wang et al., 2009; Huda et al., 2011). Although duck meat is very popular in many regions of the world (China and other countries of Asian continent) duck processing has not been researched extensively.

In Spain, one-fifth of the total meat products manufactured are dry fermented sausages (Fernández et al., 1995). "Salchichón" is a typical Spanish dry cured sausages and their manufacture implies, in a general way, three well-defined phases: mixing of ingredients, fermentation and drying.

The influence of fat level on physico-chemical and sensory characteristics has been studied in sausages elaborated with pork meat. However, there are seldom studies about sausages manufactured with duck meat. Besides, an excessive reduction of fat can have influence on the desired flavour and in the texture of

the dry-cured sausages, resulting in decreased demand by consumers.

Thus, the aim of the present study was to investigate the effect of fat level on chemical characteristics such as proximate composition, colour parameters, texture analysis and sensorial profile of dry-cured duck "salchichón".

Material and Methods

Dry Fermented Sausages

In order to carry out this study, forty units of duck sausages were manufactured in the pilot plant of the Meat Technology Center of Galicia twenty of which were manufactured only with lean duck (*pectoralis major* without added fat) and the other ones (20 units) were manufactured with 90% of lean and 10% of back fat. The lean and back fat duck were ground through a mincing plate with diameter 10 mm and vacuum minced with 50 g per kg of supplement "542 Salchichón" from Laboratorios Ceylamix (Valencia, Spain) composed, with unknown proportions, of salt, dextrin, spices, milk protein, monosodium glutamate (E_{621}), phosphates (E_{450i} and E_{451i}), sodium erythorbate (E_{316}), potassium nitrate (E_{252}) and colorant (E_{120}). The meat mixture was maintained at 3-5ºC for 24 h and then stuffed into collagen casings with diameter 55-60 mm (Fibran, S.A., Girona, España) being the final weight of each sausage of around 550 g. Sausages were transferred to a drying-ripening chamber where they were kept for 49 days at 11ºC and 75-80% of relative humidity.

In order to prepare the samples for analysis, after removing and discarding the outer casing of each dry-cured duck sausage unit, the edible part was ground in a Moulinette micer (Moulinex/Swan Holding Ltd., Brimingham, UK) until a homogeneous mass was obtained. After the moisture content and pH were determined, the samples were stored in airtight bottles, frozen at -80ºC, for no longer than 4 weeks prior to further analysis. Sensory analysis was carried out at the end of the process (after 49 days of ripening) in 5 sausage units.

Analytical Methods

1) Physico-chemical Analysis (pH Colour and Chemical Composition)

The pH of samples was measured using a digital pH-meter (Thermo Orion 710 A+, Cambridgeshire, UK) equipped with a penetration probe. Colour measurements were carried out using a CR-600d colorimeter (Minolta Chroma Meter Measuring Head, Osaka, Japan) with pulsed xenon arc lamp, 0º viewing angle geometry and 8 mm aperture size. Each sausage was cut and the colour of the slices was measured three times for each analytical point. CIELAB space (CIE, 1976): lightness, (L*); redness, (a*); yellowness, (b*) were obtained. Before measurements on each series, the instrument was calibrated using a white ceramic tile (D65).

Moisture, fat, protein (Kjeldahl N x 6.25) and ash were quantified according to the ISO recommended standards 1442:1997 (ISO, 1997), 1443:1973 (ISO, 1973), 937:1978 (ISO, 1978), and 936:1998 (ISO, 1998), respectively. Briefly, moisture percentage was calculated by weight loss experimented by the sample (5 g) maintained in the oven (Memmert UFP 600, Schwabach, Germany) at 105ºC, until constant weight. Ash percentage was calculated by weight loss experimented by the sample (5 g) maintained in a muffle furnace (Carbolite RWF 1200, Hope Valley, UK) into a porcelain capsule at 600ºC until constant weight. For the determination of fat content samples (3 g) were subjected to a liquid-solid extraction using hexane in an extractor apparatus (FOSS Soxtec Avanti 2050, Höganäs, Sweden) extractor during 3 h. Previously samples were hydrolyzed with HCl in a FOSS Soxtec System (2047 SoxCap, Höganäs, Sweden). Fat content was calculated by gravimetric difference. Protein content was determined according to Kjeldahl Total Nitrogen method, multiplying the total nitrogen content by 6.25. Sample (1 g) was subjected to reaction with sulphuric acid (cooper sulphate was employed as a catalyst) in a digester (Gerhardt Kjeldatherm KB, Bonn, Germany). Organic nitrogen was transformed to ammonium sulphate, which was distillate in alkali conditions in a distillation apparatus (Gerhardt Vapodest 50 Carrousel, Bonn, Germany).

2) Texture Analysis: Warner-Bratzler (WB) test

Dry fermented sausage slices of 1x1x2.5 cm (height x width x length) were used for texture analysis. All samples were cut at a crosshead speed of 3.33 mm/s. The Texture Analyzer (TA-XT.plus, Stable Micro Systems, Vienna Court, UK) was used according to AMSA (1995) guidelines. Samples were completely cut using a WB shear blade with a triangular slot cutting edge (1 mm of thickness). Maximum shear force (MØller, 1980), shear

firmness (Brady and Hunecke, 1985) and total necessary work performed to cut the sample were obtained. The first one, showed by the higher peak of the curve force-time, represents the maximum resistance of the sample to the cut. Shear firmness is represented by the slope from the beginning of the cut up to the highest point of the curve force-time and total work by the area under the curve.

3) Sensorial Analysis

The sensory panel evaluation was conducted with ten panellist (3 men and 7 females) selected from Meat Technology Centre of Galicia. Panellists were trained according to methodology proposed by ISO regulations (ISO 8586-1:1993 and ISO 8586-2:2008) during three months with the attributes and the scale to be used. The first two sessions were an introduction to sensory evaluation. During the nine following sessions, the panel constituted a list of attributes by consensus by the display of 6 different traditional Galician dry-cured sausages. The last 9 sessions corresponded with the evaluation of the dry-cured duck "salchichón". The casing was removed and then, the sausages were cut into slices with thickness approximately 4 mm and finally stored at room temperature on white plastic dishes. The samples were individually labelled with three-digit random numbers. Eleven sensory traits of dry-cured duck "salchichones", grouped in appearance (fat distribution, fat level and fat/lean cohesiveness), odour (black pepper, spices, lactic acid and mould), taste (acid and saltiness), and texture (hardness and juiciness) were assessed according to methodology proposed by ISO regulations (ISO 6564:1985, ISO 3972:1991, ISO 11036:1994 and ISO 5496:2006)

The intensity of every attribute was expressed on a structured scale from 0 (sensation not perceived) to 9 (maximum of the sensation). During sensory evaluation, the panellists were situated in private cabinet illuminated with red light, according to ISO regulations (ISO 8589 (2007). Water to clean the palates and remove residual flavours was used at the beginning of the session and between samples.

4) Statistical Analysis

For the statistical analysis of the results of physicochemical traits, instrumental texture measurements and sensory characteristics, an analysis of variance (ANOVA) of one way using SPSS package (SPSS 18.0, Chicago, IL, USA) was performed for all variables considered in the study. Correlations between variables were determined by correlation analyses using the Pearson´s linear correlation coefficient with above statistical software package mentioned. Principal components analysis (PCA) was also employed as the method for extraction and performed on the correlation matrix.

Results and Discussion

Physico-chemical Properties

Table 1 shows physico-chemical properties, colour parameters and instrumental texture measurements of two batches of duck "salchichones" studied. The pH values did not show significant differences ($P>0.05$) between batches. As reported by Bover-Cid, et al. (2001) in some ripened meat products processed at low temperatures, fermentation was limited and thus the pH failed to decrease by more than 0.2-0.4 units. Indeed, during the drying and maturation phases, the pH may return to similar initial values due to the liberation of peptides, amino acids and ammonia from proteolytic reactions. Our pH final values were similar to those that found in other varieties of sausages (Beriain et al., 1993; Casiraghi et al., 1996; Mateo et al., 1996; Lorenzo et al., 2000; Franco et al., 2002; Roseiro et al., 2010, Lorenzo et al., 2011). However, some authors (Gimeno et al., 2000; Muguerza et al., 2002; Salgado et al., 2005; Van Schalkwyk et al., 2011) have found, at the end of the ripening process, pH values lower than ours (below 5). The relatively high pH values observed in dry-cured duck "salchichón" indicated that the lactic fermentation was not very intense and the non-addition of sugars in the mass formula could be one of the causes of this phenomenon.

Insignificant differences ($P>0.05$) were also observed in moisture content between the two batches manufactured although there was no fat batch showed the highest values of moisture (33.63% *vs*. 33.59%). These results were in agreement with those reported by Olivares et al. (2010) and Lorenzo et al. (2011) who found higher water content in low fat sausages. Our moisture values were similar to those found by other authors (Gimeno et al., 2000; Salgado et al., 2006) in sausages with the same dry-ripening time used in this study, while Franco et al. (2002) and Salgado et al. (2005) observed final values below 30% in Spanish dry-cured sausages. Correlation test indicated that moisture contents were not positively related to instrumental colour attributes (Table 2). These results were in agreement with that found by Gimeno et al.

(2000) who reported that L* values of Spanish dry-fermented sausage were not affected by the moisture content.

Fat content showed significant differences (P<0.001) between batches. This outcome was expected because the batches were manufactured with different fat content. The reduction in moisture during ripening process produced the increase in fat content and at the end of the process the sausages reached a fat content of 10.19 and 22.36% for batches manufactured without and with fat, respectively (Table 1). Our fat values were within the range (between 30% and 66% of dry matter) of those observed by other authors in other sausage varieties (Gimeno et al., 2000; Lorenzo et al., 2000; Franco et al., 2002; Salgado et al., 2005; Olivares et al. 2010, Lorenzo et al. 2011) with the exception of "Soppressata Molisana" that showed a level of 26% (Coppola et al., 1997). It was found from correlation test that fat content was positively related to L* (r = 0.86; P<0.01), b* (r = 0.75; P<0.01) and juiciness (r = 0.84; P<0.01), and negatively correlated to pH (r = -0.58; P<0.01), a* (r = -0.71; P<0.01), ashes (r = -0.87; P<0.01), protein (r = -0.89; P<0.01), firmness (r = -0.89; P<0.01), shear force (r = -0.85; P<0.01) and hardness (r = -0.88; P<0.01) (see Table 2). Protein content, also showed significant differences (P<0.001) between batches (43.06 *vs*. 34.27% for batches manufactured without and with fat, respectively).

TABLE 1. CHEMICAL, COLOUR PARAMETERS AND TEXTURAL TRAITS OF TWO BATCHES OF DRY-CURED DUCK "SALCHICHONES" STUDIED

	Without fat	With fat	SEM	Sig
Chemical Composition				
pH	5.62±0.11	5.52±0.09	0.03	n.s.
Moisture (%)	33.59±3.79	33.63±2.62	0.69	n.s.
Intramuscular fat (%)	10.19±0.73	22.36±4.25	1.55	***
Protein (%)	43.06±2.93	34.27±3.82	1.25	***
Ashes (%)	5.83±0.33	4.88±0.41	0.13	***
Colour Parameters				
Lightness (L*)	29.24±1.98	36.10±3.71	1.03	***
Redness (a*)	18.61±1.87	15.55±2.36	0.58	**
Yellowness (b*)	7.25±1.64	10.40±1.82	0.52	**
Textural Parameters				
Shear force (kg/cm2)	7.74±1.08	5.32±1.37	0.38	***
Firmness (kg/cm2)	1.27±0.37	0.66±0.24	0.10	***
Total Work (kg*s)	83.39±13.73	64.81±8.03	3.18	**

Significance: *** (P<0.001), ** (P<0.01), n.s. (P>0.05). SEM is the standard error of the mean

Significant differences (P<0.001) were observed respect to ashes content (5.83 *vs*. 4.88%, for batches manufactured without and with fat, respectively). The correlations indicated that ashes content was positively related to protein content (r = 0.96, P<0.001) and negatively correlated to fat content (r = -0.87, P<0.001) (see Table 2). Our ashes values were higher than that found in a previously reported dry-cured duck sausages (below 3.3%) (Lorenzo et al., 2011), but most of these sausages had an ashes content between 7% and 10% of total solids (Coppola et al., 1997; Gimeno et al., 2000; Lorenzo et al., 2000; Franco et al., 2002).

Fat level affected colour parameters (L*, a* and b*). In our study, the highest fat levels produced lightness sausages (29.24 *vs*. 36.10, P<0.001 for batches manufactured without and with fat, respectively) and in agreement with that reported previously by other authors (Papadima and Bloukas 1999; Muguerza el al., 2002; Soyer et al., 2005; Olivares et al., 2010; Lorenzo et al., 2011). The lightness was negatively correlated with protein content (r = -0.92, P<0.01) and positively correlated with fat content (r = 0.86, P<0.01) (Table 2). With respect to a* values, an increase in redness was observed with a decrease of fat level (18.61 *vs*. 15.55, P<0.01, for batches manufactured without and with fat, respectively) and in agreement with that reported previously by Soyer et al. (2005). These authors reported that the speed of the formation of nitrosylmyoglobin was fast in low fat sausages and low fat content resulted in better colour development. In our study, redness was positively correlated with protein content (r = 0.67, P<0.01) and negatively correlated with fat content as well(r = -0.71, P<0.01) (Table 2). Finally, the yellowness was higher in high fat sausages than that of low fat sausages (10.40 *vs*. 7.25, P<0.01, for batches manufactured without and with fat, respectively). In this case , a positive correlation with fat content (r = 0.75, P<0.01) and negative with protein content (r = -0.81, P<0.01) (Table 2) were also observed.

Textural properties have been related in meat products to pH, moisture, fat, salt and protein. In our work, a significant correlation was found(r = 0.61, P<0.01; r = 0.86, P<0.01; r = -0.85, P<0.01, r = 0.90, P<0.01; with pH, ash, fat and protein, respectively) (Table 2). Shear force increased with a decrease of fat content

TABLE 2. CORRELATIONAL ANALYSIS (CORRELATION COEFFICIENTS, R) OF THE PHYSICOCHEMICAL PROPERTIES, COLOUR PARAMETERS, INSTRUMENTAL TEXTURAL TRAITS AND SENSORIAL TEXTURE OF TWO BATCHES OF DRY-CURED DUCK "SALCHICHONES" STUDIED

	pH	L*	a*	b*	Moisture	Ash	Fat	Protein	Firmness	Total work	Shear force	Hardness	Juiciness
pH	1.00												
L*	-0.71**	1.00											
a*	-0.45**	0.77**	1.00										
b*	-0.55*	0.91**	0.95**	1.00									
Moisture	-0.42	0.24	0.16	0.23	1.00								
Ash	0.79**	-0.91**	-0.64**	-0.77**	-0.38	1.00							
Fat	-0.58**	0.86**	0.71**	0.75**	-0.05	-0.87**	1.00						
Protein	0.76**	-0.92**	0.67**	-0.81**	-0.37	0.96**	-0.89**	1.00					
Firmness	0.71**	-0.89**	-0.75**	-0.85**	-0.40	0.88**	-0.77**	0.90**	1.00				
Total work	0.06	-0.51*	-0.60**	-0.55*	0.17	0.51*	-0.73**	0.55*	0.45*	1.00			
Shear force	0.61**	-0.89**	-0.80**	-0.88**	-0.25	0.86**	-0.85**	0.90**	0.92**	0.66**	1.00		
Hardness	0.44	-0.71**	-0.54	-0.62	-0.01	0.78**	-0.88**	0.79**	0.68**	0.64**	0.68**	1.00	
Juiciness	-0.38	0.71**	0.53*	0.63**	0.02	-0.74**	0.84**	-0.75**	-0.67**	-0.66**	-0.70**	-0.94**	1.00

(7.74 *vs*. 5.32 kg/cm², for batches manufactured without and with fat, respectively); which was in agreement with other authors (Matulis et al., 1995; Mendoza et al., 2001; García et al., 2002; Liaros et al., 2009; Salazar et al., 2009; Olivares et al., 2010; Lorenzo et al., 2011) who observed that hardness decreased with increasing fat in dry fermented sausages. However, Jimenez Colmenero et al. (1996), in bologna sausages, observed that, when the fat level was reduced, there was a significant decrease in the penetration force.

Sensory Characteristics

Mean scores given by the panellists for two batches manufactured are shown in Table 3. Only fat distribution, fat level, cohesiveness, hardness and juiciness were significantly different respect to fat level. Regarding appearance, "salchichón" batch manufactured with fat showed high scores for fat distribution (5.91 *vs*. 2.22) and fat level (6.18 *vs*. 2.22), while fat/lean ratio obtained a low score (6.00 *vs*. 7.33). Concerning odour properties, black pepper was a dominant spice in both "salchichones" , which was in agreement with Roncales (1995) who specified that the major distinctive characteristics among dry-cured sausages were the spices. "Salchichón" is distinguished by the presence of black pepper and "chorizo" is characterized by "pimenton" (Spanish paprika, *Capsicum annum*). Lactic acid is the main acid resulting from the fermentation of these products (Fehlhaber, & Janetschke, 1995; Mateo, & Zumalacárregui, 1995; Varnam, & Sutherland, 1995) although this compound produces a fundamental sour taste without other aromatic top-notes (Lotong et al., 2000), while mould odour is associated with 1-octen-3-ol which exhibits the typical odour of mushroom (Meynier et al., 1998). However in our study, both attributes showed low scores for lactic acid and mould odour (Table 3).

On the other hand, "salchichones" also showed low scores for acid taste and saltiness (Table 3). However, Ruiz Peréz-Cacho et al. (2005) found a stronger acid and salty taste in "salchichones" processed in the major meat industries of Spain, located in the northeast and central areas of the country. With regard to texture attributes, hardness showed higher scores in "salchichones" manufactured without fat (7.0 *vs*. 2.72, P<0.001) while juiciness showed higher values in "salchichones" manufactured with fat (7.63 *vs*. 3.55, P<0.001). Correlation tests indicated that hardness was positively correlated with protein content (r = 0.79, P<0.01) and with shear force (r = 0.68, P<0.01) while negatively related with fat content (r = -0.88, P<0.01), however, juiciness was positively related with fat content (r = 0.84, P<0.01) and negatively correlated with protein content (r = -0.75, P<0.01) as well as with shear force (r = -0.70, P<0.01) (Table 2).

TABLE 3. SENSORY PROPERTIES OF TWO BATCHES OF DRY-CURED DUCK "SALCHICHONES" STUDIED

	Without fat	With fat	SEM	Sig
Appearance				
Fat distribution	2.22±0.66	5.91±1.57	0.51	***
Fat level	2.22±0.83	6.18±1.53	0.53	***
Fat/lean cohesiveness	7.33±0.50	6.00±0.44	0.18	***
Odour				
Black pepper	4.55±1.51	4.27±1.10	0.28	n.s.
Spices	6.11±0.78	5.72±0.90	0.19	n.s.
Lactic acid	0.44±1.01	0.36±0.67	0.18	n.s.
Mould	0.44±0.88	0.37±0.81	0.18	n.s.
Taste				
Acid	1.33±1.00	1.00±0.77	0.19	n.s.
Saltiness	2.66±0.86	2.81±0.40	0.14	n.s.
Texture				
Hardness	7.00±0.50	2.72±0.64	0.50	***
Juiciness	3.55±0.72	7.63±0.50	0.48	***

Significance: *** (P<0.001), n.s. (P>0.05). SEM is the standard error of the mean

Principal Components Analysis

PCA allows the acquisition of a better overall idea of the relation among variables. The results of the first two principal components are plotted in Figure 1. The PCA showed that the first two components described about 81.2% of the variation of the original variables. Figure 1 shows a clearly separation between "salchichones" manufactured without and with fat. As it can be seenthat mean values for "salchichones" manufactured without fat were situated at the negative side of PC1 and in the positive side of PC2, while "salchichones" manufactured with fat were located at the positive side of PC2.

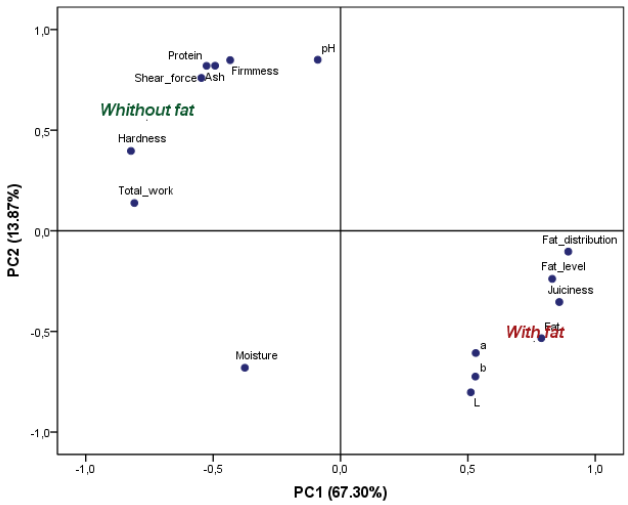

FIG. 1. RELATIONSHIPS BETWEEN "SALCHICHONES" MANUFACTURED WITHOUT AND WITH FAT AND PHYSICO-CHEMICAL AND SENSORY PROPERTIES OBTAINED BY PCA. PROJECTION OF THE VARIABLES AND TWO GROUPS IN THE PLANE DEFINED BY THE FIRST TWO PRINCIPAL COMPONENTS.

The PC1 axis was mainly characterized by fat distribution, fat level, juiciness and fat content on the right side, and hardness and total work on the left side. The variables positively aligned with PC2 were pH, ash, protein, firmness and shear force, while the variables luminosity, redness, yellowness and moisture were negatively aligned with PC2.

Conclusions

Inclusion of fat affected significantly protein, ashes and fat content of dry-cured duck "salchichón". The highest fat level produced an increase in the lightness as well as yellowness and a decrease in redness of sausages. The fat reduction in dry fermented duck sausages had a significant effect on the sausage texture due to an increase in hardness.

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